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THESIS

AN ECONOMIC ANALYSIS OF NAVAL
INTEGRATED VS. CONVENTIONAL
PERSONNEL SYSTEMS

by

Kathy Cambridge Sapp

June 1983

Thesis Advisor: W. McGarvey

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An Economic Analysis of Naval Integrated vs. Conventional Personnel Systems

by

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ABSTRACT

Given the Navy's basic training/readiness objectives and the resources at its disposal, this research examines time streams' costs and benefits. Utilizing cost-benefit analysis techniques this research investigates potential tradeoffs available to Navy policymakers as a result of human capital training investment within conventional and integrated personnel systems. Findings suggest that an integrated personnel system enhances technical skill development, personnel retention and job performance at decreased cost relative to a conventional personnel system.

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I. INTRODUCTION

A. MANPOWER PERSONNEL TRAINING PROBLEM

Operating in a complex and dynamic environment where variables such as population demographics, increasing technological complexity of new weapons systems, and labor market competition interact, the Navy strives to sustain its manpower requirements. And, with the reenactment of the all-volunteer force, [Ref. 1], the cost of military manpower has increased sharply -- partly as a result of lessening military-civilian differences. Additionally, advances in technology have transformed the occupational needs of the services.

With few exceptions, the military has rarely been immune to fluctuations in the economy; recently, for example, an increased demand for specialists and technicians has accelerated cost increases for training the multitude of junior personnel who enter the services with little or no developed skills. Such cost increases reflect sizeable investments in highly valued skill development in an environment where personnel are not contracted for life. As a competitor in the labor market the Navy must pay a significant price to retain skilled personnel and thus, gain some additional return on its earlier human capital training investments.

Essentially, manpower requirements are a function of the kinds and numbers of skilled people needed in the service and the people within the total population available to serve. If only a few members of the population who are available to join the military have the requisite skills then, selection and training of persons with the propensity to learn the skills is necessary.

Given the military's dependence on hardware and complex technological systems, a conceptual model exists that is applicable as a tool for integrating man-hardware or man-machine principles relative to manpower selection and training. Quite simply, man is an organism capable of processing information; thus, man is also an "intelligent" organism capable of long-term memory/recall of past events. Long-term memory is a function of: (1) sensation, (2) perception, (3) short-term memory, (4) decision-making and (5) motor responses. Man, as a biological organism, is susceptible to environmental, physical and psychological stress.

A machine is an assemblage of parts that transmit forces, motion and energy one to another in a predetermined manner; an instrument, a mechanism built of inert materials/resources by man, to transmit or modify the application of power, force or motion. Machines are susceptible to environmental and physical stress.

A man-machine interface implies that a medium exists for combining man with machine to produce some optimum output or product. The term "manpower" implies that personnel who are available to perform in concert with machines are appropriately trained to work with equipment/hardware of specific design that has been built with most, if not all, of man's corporeal characteristics in mind.

A significant implication of the above man-machine model is that were a hardware/machine system designed such that a large segment of the population could operate it with near optimum results then, fewer funds would need to be allocated for the selection and training of required personnel.

In summary, manpower personnel selection and training is a function of the purpose, objectives and goals for which hardware systems are acquired within the military. Unless the hardware system is built with a capacity for operation

and/or monitoring in the complete absence of man, which is seldom if ever the case, then, the equipment/mechanism as well as the selection and training process, should be developed and constructed with its human counterpart in mind.

B. CONVENTIONAL PERSONNEL SYSTEM

The conventional personnel system is driven by an annual influx of large numbers of unskilled, young people. In an uncertain manner these large numbers of recruits are in the military because an external threat (such as a new Soviet capability) has been perceived; a threat that is to be countered via armed services' missions and objectives. Expensive hardware procurements are generated by the same perceived threats. In some optimum way these large numbers of unskilled people must be matched to the hardware to fulfill the job/task requirements within weapons systems. Within the military, training is the vehicle by which the unskilled recruits are prepared to become more compatible with the ships, tanks, missile fire control and launch systems as well as a host of other hardware or machine systems. Traditionally, training expenses have been incurred in the Navy as a result of specialized training. There are three basic types of specialized training: (1) A-school or initial skill training; (2) C-school or skill progression training; and (3) F-school or functional training.

A-school training is provided primarily to recent graduates from recruit training although some enlisted personnel who have not previously been to A-school may go to A-school from fleet assignment. A-school training provides the basic technical knowledge and skills required to prepare for entry level job performance and further specialized training.

Prior to receiving rating-specific training, students may take preparatory courses which teach core material common to two or more initial skill courses. For example, the Basic Electricity and Electronics (BE&E) Preparatory course covers subjects common to many ratings, including the Electrician's Mate (EM), Communications Technician-Maintenance (CTM), Electronics Technician (ET), Aviation Electronics Technician (AT), and Fire Control Technician (FT) ratings. Students destined for these ratings attend BE&E school before receiving any initial skill training for their particular rating.

There is an initial skill or A-school course for almost all ratings. Currently, there are A-school courses for approximately 82 ratings. A sailor usually attends an A-school directly after boot camp and upon completion is considered a "striker" in the rating. This is the main or conventional training path leading to petty officer status (E4 and above) in a rating.

A C-school or skill progression training, provides the advanced knowledge, skills and techniques required to fill a particular billet. C-schools are more specialized in nature than A-schools. For example, an electronics C-school could train an ET on a particular piece of equipment or system, such as, a specific radio receiver. A person usually attends C-school early in their career; For example, as in most aviation ratings, one way to go is right after finishing A-school. Another way is for the Navy to guarantee a person skill progression training as a reenlistment incentive. In most cases this implies attending C-school before the end of the fifth year of service.

F-courses are of short duration and are generally operational in nature. In some cases F-school, or functional school training, is team training for fleet personnel who normally are on board ship or are enroute to sea duty. In

other cases it is individual training such as refresher, operator, maintenance or technical training.

C. ALTERNATIVE PERSONNEL SYSTEM

A recent alternative to the conventional personnel system described above is the Enlisted Personnel Individualized Career System (EPICS). EPICS is a career enhancement personnel system currently undergoing test and evaluation that purports to: (1) reduce attrition; and (2) achieve cost-effectiveness through the use of "deferred" shore-based training. EPICS is designed to provide apprentice sailors on-the-job experience complemented by job-performance-aids (JPA's) and self-paced instructional materials. After the EPICS sailor has adapted to shipboard life, JPA's and exportable shipboard instructional modules are further employed to ensure satisfactory job performance consonant with the individual's level of skill acquisition. Two shore-based training experiences are currently being offered throughout a four year enlistment if an EPICS sailor has demonstrated an interest and ability to benefit from shore-based technical training. Thus, technical progress, shipboard adjustment and educational opportunities are integrated into a personalized career path.

In many respects EPICS is an embellished version of current on-the-job training (OJT) paths for rating attainment. Some ratings in the Navy are earned only via OJT and many "strikers" become so designated as a result of OJT when A-school is not available. A major distinction between EPICS and traditional Navy OJT is that EPICS applies these training techniques to sophisticated technical ratings when, historically, traditional Navy OJT has been geared to less technical ratings. For example, Boatswain's Mate (BM) is a non-technical rating that is achieved only via OJT whereas

Fire Control Technician (FT), a more modern and technical rating, is usually achieved via formal school training. The FT's are the rating for EPICS test and evaluation currently being conducted by the Navy Personnel Research and Development Center (NPRDC).

D. CONVENTIONAL VS. ALTERNATIVE PERSONNEL SYSTEM

Some principal differences between EPICS and the conventional personnel system are:

1. EPICS seeks to defer large investments in training until the uncertainty concerning expected payoffs (continued availability of recipient) can be reduced. Conventional training, however, takes large numbers of newly enlisted service members directly into a formal technical training environment immediately upon completion of basic training -- before much of any expected attrition can occur.

2. EPICS personnel are trained in accordance with the actual job requirements commensurate to tasks assigned during a first enlistment period. In the initial skill and preparatory levels, conventional training is broad-based and theoretical in nature. Specific skills required for equipment and/or systems are taught at the advanced or C-school level and possibly at the F-school level; sometimes prior to the first sea assignment.

3. EPICS employs ship-board on-the-job training/job-performance-aid (OJT/JPA) techniques in smaller student-instructor ratios for job/skill familiarization during an initial sea assignment. Also, EPICS training is clustered by levels; training for subsequent levels is not administered until individual trainees demonstrate competence (and continued presence) at the previous skill level. For example, training for skill level III does not commence until skill level II is successfully mastered.

Training in the conventional system utilizes a mixture of self-paced programmed or computer managed instruction supervised by learning center instructors (LCI's) and group-paced instruction taught by a lecturing, classroom instructor. In both forms of training the student to instructor ratios are quite large. Further, each student may be going eventually to one of several different ratings.

E. SCOPE OF THESIS

This study is an evaluation of whether the conventional personnel career path utilized by the Navy yields optimal returns in terms of sufficient numbers of qualified, skilled personnel relative to Navy investments in personnel training. By utilizing human capital theory, a billet cost model, net present value, and certain general linear model derivations (stepwise discriminant analysis, discriminant analysis, regression, and multivariate analysis of variance) the costs and benefits were estimated and evaluated for these alternative career paths: (1) EPICS for the FT rating, and (2) conventional, formal, specialized training for the FT rating.

For the purposes of this study benefits are defined relative to their effect on the fundamental objectives of training. Costs are defined relative to respective opportunity costs or benefits foregone, as a result of not utilizing limited resources in the optimal of the alternative methods when the resources are instead utilized in a specific activity. The foregone benefits are thus defined relative to their potential effect on the fundamental objectives of training. Only those costs that varied among the two career paths for similar events/benefits were examined.

1. Human Capital Theory/Model

The human capital model utilized in this study was originally developed to estimate the economic returns for college attendance and other formal education [Ref. 2], but it is generally applicable to other human investments such as on-the-job training, health and migration. The model is useful for analyzing the effectiveness and interrelationships between Navy policy revisions, career personnel force structure and career force training.

The human capital model addresses three general aspects of training investments that are germane to Navy policy; the amount of training investments, the type of training provided and the timing of training. Individuals and firms in the private sector will only invest in training if the discounted present value of the returns exceeds the costs of investments. Heuristic economic arguments suggest that the Navy is investing in training far beyond this point, even after the value of training as an accession tool is taken into account [Ref. 3].

The theory of human capital distinguishes between two basic types of training, general and specific. For example, general training is that which is of value to many organizations including the Navy. In reality, of course, all training is composed of a certain proportion of general and specific elements. The distinction between general and specific training is important in assessing the value of training to an individual (in terms of potential compensation) both inside and outside the Navy. Thus, the theory may also be useful in coordinating Navy compensation and training policies.

Since optimal training investments are determined by the discounted present value of costs and benefits, the timing of those costs and returns are crucial. In general,

this implies that the longer the delay between training and use of training, the lower the net value of the investment. Related implications involving decisions on the optimal timing of training also exist for such Navy policies as sea/shore rotation and length of enlistment/reenlistment contracts.

A critical aspect of the investment decision is the way in which costs and benefits are measured. The costs of education or training include not only direct costs such as books, teachers and supplies but also indirect costs of training. These indirect costs, for example, opportunity costs, represent the foregone productivity of personnel during training and usually constitutes the major portion of training costs. Once opportunity costs are recognized, other Navy policy implications become relevant. For example, it is expensive to rotate a skilled technician to a shore billet or to provide additional training to someone who is already trained in a valuable skill. As individuals accumulate human capital, the value of their time becomes much more valuable during a training period. Thus, opportunity costs and not direct costs of training may provide the focus for determining the optimal amount of training. Ignorance or gross underestimations of the economic costs of policy changes in training may contribute to military overinvestment in training.

Although the analogy between human and physical capital provides many insights into the nature of individuals' decisions, the analogy should not be pursued too far. Human capital has a number of special properties that make it unique among the assets an individual can buy. Contrary to other assets in most developed nations, human capital cannot be sold. The owners of human capital are inextricably tied to their investment. An individual may rent out this investment to employers but, they may not sell

it in the way a firm might sell a machine it no longer needed. Human capital also depreciates in a rather unusual manner. It is totally lost upon the death of its owner, and this makes the investment rather risky. Finally, the acquisition of human capital takes substantial time; the irreversibility of time makes this process of human capital investment all the more risky. Hence, there are a number of reasons to be cautious in applying the results of capital theory to the study of the acquisition of human capital. Nevertheless, the human capital theory can be useful as an evaluative tool for considering the merits of Navy policies such as using training as a recruitment incentive, 3/3 sea/shore rotation, integration of training, compensation and contract lengths as well as other relevant issues.

II. COST ANALYSIS

A. NPRDC COST ANALYSIS

A report entitled "The NPRDC Enlisted Personnel Individualized Career System (EPICS) and Conventional Personnel System (CPS): Preliminary Comparison of Training and Ancillary Costs" [Ref. 4], estimated and compared the formal training and ancillary support costs required to qualify fire control technicians to operate and maintain the NATO Seasparrow Surface Missile System (NSSMS) using EPICS and conventional personnel system (CPS) paths. This most recent effort is but one of several documents that have been released from NPRDC in an attempt to constructively evaluate an integrated personnel system approach relative to the traditional, conventional Navy personnel system concept.

1. Assumptions

Because EPICS research, development, implementation and evaluation is so recent, significant data remains unavailable. Nevertheless, NPRDC reports have been produced. As such, costs/benefits analysis can be attempted utilizing various assumptions and definitions relevant to available data for comparison of conventional and integrated personnel systems.

The Megrditchian (1983) [Ref. 4], and earlier reports on EPICS/CPS comparisons, were conducted with assumptions relevant to economic life estimates, formal training cost components, and curricula development costs. In general, it was assumed that for the data known, and available, that such data was known with certainty.

Economic life is defined as the time period during which the specific alternatives or alternative components provide a benefit or incur a cost. The duration of economic life is influenced and limited by specific factors such as: 1) mission life, 2) physical life and 3) technical life. Mission life is the time period over which a need for the asset(s) is anticipated; physical life is the time period over which the asset(s) may be expected to last physically; and, technological life is the time period before obsolence would dictate replacement of the existing asset(s). Given these parameters, the task of evaluating the cost/benefits of EPICS and CPS was further complicated by the analysis variables themselves; each of which had to be considered in terms of economic life and the resulting cost stream.

In reference to economic life five assumptions were made; 1) EPICS and CPS had an identical perpetual economic life, 2) school curricula, training modules, JPAs, and administrative support materials were amortized over a life of ten years. These items had a physical life of five years requiring, one replacement during the ten years of economic life accomplished through maintenance; 3) maintenance cost percentages for curricula, modules, JPAs, and support materials were one percent for the first three years, five percent for the following three years, and one percent for the final four years; 4) training horizon was taken as four years for training 200 FTMs and ten years for training 500 FTMs; and 5) administrative support cost was computed for the initial year of implementation. The net present value was computed throughout this and other NPRDC reports using a ten percent discount rate. Economic life year and maintenance cost percentage estimates presented in the NPRDC report were developed through discussion with experienced Navy instructional technologists and Nato Seasparrow Missile System (NSSMS) data systems developers [Ref. 4].

Formal training cost assumptions were as follows: (1) Formal training costs for EPICS and CPS were assumed to be equal on a per week per student graduate basis [Ref. 5]. This was based on two subparameters: (a) school loss data were incomplete at the time of the April, 1983 study when all of the EPICS cohort had not entered equipment technician training (ETT) and system technician training (STT), and (b) EPICS school training used (and still does use) the same facilities as CPS schools.

(2) At the time of the Megrditichian study [Ref. 4], the curriculum for the NSSMS "C" school included 23 weeks for training in the fire control systems (FCSs) and ten weeks for training in guided missile launching systems (GMLSs). However, the NSSMS "C" school curriculum requirements were in a revision process that would combine the FCS/GMLS curricula into one, and thus, would encompass 26 weeks of training. This change permitted fair comparison of NSSMS "C" school and EPICS STT, both of which include training in FCSs and GMLSs.

(3) The training parity horizon was hypothesized as three years, at which time both EPICS and CPS students would have received basic and system training required for NEC qualification.

(4) CPS students would be NEC-qualified after they had successfully completed BE&E school, FT "A" school (phases 1 and 2), and NSSMS 'C' school (combined). EPICS students would be NEC-qualified after they had successfully completed both STT and ETT. It should be noted here that subsequent to the release of the latest NPRDC report the FT "A" school courses phases 1 and 2 were combined into one course; now 26 weeks duration instead of the previous 23 weeks.

(5) Each year, 50 EPICS students would be trained in a four year timespan to produce 200 FTMs and in a ten year period to produce 500 FTMs.

(6) The course cost discounting rate is used for 4- and 10-year horizons.

(7) EPICS student distribution per year would be a uniform mix of ETT and STT students.

It was assumed that EPICS and CPS formal training costs were equal (per week per graduate) except for costs allocated for student travel and per diem. The following assumptions were made to develop appropriate travel and per diem estimates:

(1) ETT and STT schools would be single-sited at San Diego and Mare Island during EPICS test and evaluation [Ref. 6].

(2) CPS school costing data indicated that student travel constituted an average of 3.3 percent of training costs [Ref. 7].

(3) An equal number of ETT and STT trainees traveled between the east and west coasts.

(4) Travel and per diem costs for ETT and STT were $1,354 and $1,585 respectively, based on an arithmetic average for travel.

TABLE I

NPRDC CPS/EPICS School Travel Scenarios

Scenario	School	Location	Travel Status*
		CPS	
1	Recruit training	Great Lakes	---
	BE&E	Great Lakes	PCS
	FT "A" (1 & 2)	Great Lakes	PCS
	NSSMS "C"	Dam Neck or Mare Island	PCS
2	Recruit training	San Diego	---
	BE&E	San Diego	PCS
	FT "A" (1 & 2)	Great Lakes	---
	NSSMS "C"	Dam Neck or Mare Island	PCS
3	Recruit training	Orlando	---
	BE&E	Orlando	PCS
	FT "A" (1 & 2)	Great Lakes	PCS
	NSSMS "C"	Dam Neck or Mare Island	
		EPICS	
1	Recruit training	Great Lakes	---
	ETT	San Diego	TDY
	STT	Mare Island	TDY
2**	Recruit training	San Diego	---
	ETT	San Diego	TDY
	STT	Mare Island	TDY
3	Recruit training	Orlando	---
	ETT	San Diego	TDY
	STT	Mare Island	TDY

*PCS=Permanent change of station; TDY=temporary duty.
**The EPICS test and evaluation has included recruits from the San Diego recruit training pipeline only.

Travel costs for CPS students are already included in CCS training cost figures. Having assumed that school training costs for EPICS and CPS were equal per unit time per student/graduate, the EPICS costs then required adjustment for anticipated travel differences between the two training paths. This was done by (1) subtracting the percentage of travel costs identified for CPS travel from course costs and (2) adding travel costs for TDY travel and per diem to EPICS course costs.

The teaching methodology for the schools in EPICS and CPS had to be specified and related to the requisite curriculum to be used to account for curriculum development costs. EPICS and CPS included different instructional delivery modes and, therefore, different curriculum methodologies. The individualized modular method was being used in BE&E and ETT courses; in the FT "A", "C" and STT courses the conventional lecture method was utilized.

The following assumptions and definitions related specifically to curriculum types were used in estimating the costs of the two instructional techniques.

(1) The EPICS ETT curriculum was designed to be similar to a combination of that in BE&E and FT "A" (Phase I);

(2) The EPICS STT curriculum was designed to be similar to a combination of that in FT "A" (Phase II) and NSSMS "C" (combined) schools.

(3) Curriculum development costs for CPS and EPICS were considered equal in terms of cost per module and cost per unit time of instructional material developed. (4) EPICS ETT course development cost was computed to be $20,000 per module, which was used to estimate the curriculum development cost for the 30 module comprising BE&E. (5) EPICS STT cost per week of instructional material developed

was computed to be $5,500, which was used to estimate the cost of developing curricula for FT "A" (Phases I and II) and NSSMS "C" (combined) schools.

Job readiness parity was defined earlier as being obtained in EPICS through formal course work (ETT and STT). EPICS also includes self-study course work using self-paced instruction in various career stages. The development costs for these modules were totaled at an expense of $362,330 using the one, five and one percent maintenance ratios mentioned above. A one-time development/production investment of $362,330 and the varying discounted recurring maintenance costs were amortized over ten years of economic life.

Job-performance-aids (JPAs) were developed for EPICS to aid the technician during maintenance duty performance on the NSSMS at a competency level commensurate with ship and system requirements and the individual's skill background and experience. Again, at the time of the Megrditchian (1983) study refcom 4 two types of JPAs had been developed for use at the apprentice technician levels; these are the partially proceduralized job performance aid (PPJPA) and the fully proceduralized job performance aid (FPJPA). Primary differences between the two are the degree of proceduralization, the number of illustrations included, the level of detail included, and the complexity of tasks represented.

Development effort for both types of JPAs included front-end analysis, task analysis, and job design, all falling in the engineering analysis cost category, which comprised 94 percent of total JPA costs. That value was within documentation cost guidelines for development of normal to complex procedural material (67-97%). In determining the cost of JPA development and production, actual contractor costs were used. The combined JPA net present

value was $824,200. In estimating production and development costs for an equivalent number of maintenance requirement cards (MRCs) it was hypothesized that a cost comparison would be much more valid if the contractor developing and producing JPAs were to provide cost data for developing and producing MRCs. Therefore, estimates were made on (1) the number of procedures that are directly equated to the number of MRCs and (2) the average number of pages per procedure.

The areas of administrative program material and staff support were more difficult to assess than any of the other variables mentioned above. Before deciding to include or not include costs in this category, consideration was given to whether or not: (1) the cost would be incurred during the actual operational implementation of EPICS, and (2) that the cost-incurring effort might be performed routinely by established organizational personnel or require additional resources. It was determined that a cost item would be allowed and counted if effort or a resource: (1) was expended during general implementation, and (2) could not be accomplished routinely by existing resources.

2. Data

The formal training cost estimates were based on CNET 1979 Course Costing System (CCS) statistical data. These data reflected the cost per student values for BE&E, FT "A" (Phases 1 & 2), and NSSMS "C" schools. Tables II and III summarize costs/student and costs/equivalent graduate CPS and EPICS formal school costs as estimated by Megrditchian (1983) [Ref. 4].

The report contains other data tables on Individual Training Cost for CPS/EPICS, EPICS and CPS Training Cash Flow (Single Student, 6-year obligor), EPICS and CPS Curriculum Development Costs, EPICS and CPS Curriculum Cash

TABLE II

CPS Formal School Costs

Item #	Course/ School	Duration (Weeks)	Cost/Student ($) 1979	Cost/Student ($) 1981*	CPEG** ($) 1981
1	EE&E	10	3,200	3,872	4,178
2	FT "A" (Phase 1)	11	3,500	4,235	4,346
3	FT "A" (Phase 2)	12	3,500	4,235	4,498
4	NSSMS "C" (FSC)	23	13,500	16,335	17,299
5	NSSMS "C" (GMIS)	10	6,000	7,260	7,688
6	NSSMS "C" (Comb.)	26	15,364	18,590	19,687
	Total (Items 1,2,3, and 6 only)				32,709

*Reflected cost per student in 1981 dollars, assuming ten percent inflation per year since 1979. The convention of inflating first and discounting later is used (DOD, 1972).

**The cost per student was converted to cost per equivalent graduate (CPEG), using the following relationship:

CPEG=Total Course Cost/Equivalent Graduate

EG=(Total Course Student Weeks minus Total Course Attritees Weeks) divided by Total Course Length (Weeks)

Flow Data, EPICS Instructional Module Costs, EPICS Instructional Module Cash Flow, NSSMS JPA/MRC Comparison Data, EPICS Job Performance Aid (JPA) Cash Flow Data, Technical Publication Unit Costs, CPS Maintenance Requirement Card (MRC) Cash Flow Data, EPICS Administrative Material and Staff Support Cash Flow Data, Training and Ancillary Costs of EPICS and CPS and Cost by Basis for Comparison. For the sake of brevity and the focus of the thesis on the initial skill training segment of the two personnel systems being studied, these tables will not be summarized.

TABLE III

EPICS Formal School Costs

Item #	Course/ School	Duration (Weeks)	Cost/Week $	CPEG Uncorrected* Travel	CPEG Correct** Travel
1	ETT	14	395	5,530	6,700
2	STT	18	757	13,626	14,761

*Based on CPS weekly cost per equivalent graduate (CPEG) with imbedded 3.3 percent CPS travel cost.
**Based on estimated EPICS TDY travel cost.

3. Methodology

The EPICS test and evaluation project has provided the career path and most component costs for technical preparation for both personnel systems. The training path and support structure for each personnel system was determined. Two cohort population levels were hypothesized for training for each path: one of 200 FTMs, to be consistent with initial estimates of the EPICS test and evaluation population, and one of 500 FTMs, to represent long-term NSSMS requirements. Individual training and ancillary support costs for each population were estimated, discounted, and expressed in terms of base year dollars. Finally, the cost components for each system were aggregated and expressed in terms of net present value (NPV) and equivalent uniform annual cost (EUAC). Costs allocated to formal training included those items identified by Navy CCS in the categories of labor, supplies, contracts, etc., for cost items such as travel, pay, facilities, housing, overhead and support.

TABLE IV

EPICS and CPS Training Cash Flow Data

Project* Year	Student Cohort	Amount $ Recurring	Discount Factor (10% Rate)	Cost $	
EPICS					
1-4	200 (50 per year	1,073,050	3.326	3,568,964	NPV
1-10	500 (50 per year	1,073,050	6.447	6,917,953	NPV
				1,073,050	EUAC
CPS					
1-4	200 (50 per year	1,635,450	3.326	5,439,507	NPV
1-10	500 (50 per year	1,635,450	6.447	10,543,746	NPV
				1,635,450	EUAC

*Discounting period in years.
NPV=Net Present Value
EUAC=Equivalent Uniform Annual Cost

Training costs were estimated for preparing 200- and 500 person groups of Nato Seasparrow Missile System (NSSMS) fire control technicians (FTMs) via the EPICS and CPS training paths using a common level of total job preparedness achieved through both the EPICS and CPS pipelines; the distinction between the two tracks being that the primary EPICS training goal during the early years of enlistment is achievement of job readiness and not academic maturity. While academic equivalence is attainable via EPICS, it comes later when the choices about job specialty and career orientation have been decided. In terms of job preparedness parity, EPICS and CPS were considered equivalent at NEC 1148 qualification.

4. Conclusions

The findings of the analysis were determined to be preliminary at best; however, empirical evidence presented in the report suggests that: (1) EPICS can be expected to reduce initial skills training investment cost leading to FTM NEC qualification by approximately one-third over the current training approach; and (2) EPICS provides an opportunity for cost reduction in technical preparation, even when ancillary support costs, including curriculum development, instructional modules, JPAs, and staff support, are combined with training costs.

B. THESIS COST ANALYSIS

1. Assumptions

One of the underlying assumptions of the cost analysis of this thesis is that the program development costs allocated to EPICS will be treated as sunk costs as will the costs of maintaining the training facilities, and travel [Ref. 8: p. 9]. The reason for doing this is to analyze the two personnel systems in terms of a long-run planning and decision-making scenario.

Once the R & D phase of EPICS is determined to be complete policymakers will review the cost/effectiveness of the two processes and choose one over the other as a vehicle for develcping the best qualified technician at least cost. At that point in time the programs will be evaluated relative to costs for routine operation, student volume, recruiting personnel, etc.

For these reasons more current cost values will be utilized and net present value calculations performed only in those instances where the cost differences are clearly distinct and identifiable with one system or the other; for

example, when equivalent training is conducted at different points in the careers of individuals within the two systems. Also, inflation will be ignored because no [Ref. 8: p. 10], because no salient evidence exists to indicate that the cost of either the conventional or integrated systems will fluctuate more or less than future inflation rates.

A final assumption is made about initial skill training. For the purpose of this analysis initial skill training is defined as that training received in preparation of skill progression training or "C" school training. For example, in the conventional system initial skill training for the FT rating would include BE&E, FT "A" school Phases 1 and 2. Skill progression, or "C" school training would be equivalent to the NSSMS course of instruction. This distinction will be more apparent in the cost analysis to follow.

2. <u>Data</u>

The data used in this cost analysis are long-run average costs processed from the Chief of Naval Education Training (CNET) Per Capita Cost (PCC) database [Ref. 9]. These are the long-run average costs per student-week for the FT "A" school initial skill training pipeline (before the conversion of phases I & II to one course).

These costs per student-week do not include the costs associated with the students' attendance. They are just the cost of providing the training -- instructor salaries and allowances, etc; the cost of supplies and maintenance, etc. Although raw data was preferred for this analysis, it was unattainable from CNET due to perceived problemmatic procurement, sorting, interpretation, reliability/validity and timeliness issues.

TABLE V

FY 1981 Long-Run-Average Costs (LRAC)

CDP	DAYS	Long-Run Average cost per student-week
6359	79	110
6377	75	100
6376	82	161

where, CDP 6359=BE&E in San Diego
CDP 6377=FT "A" Phase I in Great Lakes, IL.
CDP 6376=FT "A" Phase II in Great Lakes, IL.

3. Methodology

When analyzing the discounted present value criterion for investment, a specific mathematic formula is used to compute the amount of money that is to be paid at different periods in time; given that one dollar today is of more value than a dollar that is paid at a later period [Ref. 10: p. 439]. From the view point of the investor, in this case the Navy, today's dollar is best invested to earn interest at the current rate, r. To delay the investment could incur the loss of interest, a benefit foregone, and possibly result in the inability to obtain a good or resource, perhaps a human resource, at a later time.

In this thesis the net present value formula is applied in a cost comparison of initial skill training investments for 1148 NEC FTMs with 4 year obligations (4YO). Due to recent changes in contract length requirements it may no longer be possible to strike for FTM with a 4 YO contract. Nevertheless, the 4YO, FTM assumption serves as a sufficient point of departure for this analysis. Utilizing

TABLE VI

Net Present Value Formulae

In general, a dollar today grows to (1+r) dollars next year. The formula for present value of one dollar is:

$\$1/(1+r)$, which is

the amount to be invested today at an annual interest rate,

r,

to yield one dollar in one year.

Also, the present value of one dollar payable in some number of years,

n,

is : $\$1/(1+r)^n$,

where for a series of payments in years 1, 2, and 3

net present value $= 1/(1+r)^1 + 1/(1+r)^2 + 1/(1+r)^3$.

the second formula presented in table six, a general comparison can be made between the EPICS and CPS personnel systems relative to initial skill training. In the NPRDC report it was assumed that: (1) the EPICS ETT school curriculum was designed to be similar to a combination of that in BE&E and FT "A" (Phase 1) schools; and (2) the EPICS STT school curriculum was designed to be similar to a combination of that in FT "A" (Phase 2) and NSSMS "C" (combined) schools [Ref. 4: p. 10]. This assumption is carried further in that if the curricula are similar then there are cost similarities in the method of presentation, the quality of the instructors, as well as the facilities and supplies being utilized, etc. Thus, using the long-run average costs in table VI, the NPVs for EPICS and CPS were approximated.

EPICS initial skill training consists of ETT and STT; based on the abovementioned similarities, the cost of ETT is approximately equal to $110 + $100 per student-week for 14 weeks; $210 x 14 = a cost of approximately $2,940 per student. The cost of STT is approximately equal to $2,940/.41; about $7,171, with some proportion of that amount attributable to the costs of the FT "A" (Phase 2) equivalent of the STT curriculum and some proportion attributable to the NSSMS segment of STT; just what value the proportions may be is beyond the scope of this study particularly since the calculations presented here are academic estimates used to facilitate the analysis of the EPICS and CPS personnel systems (the ratio ETT/STT, using CPEG uncorrected for travel, was used to calculate a percentage value of ETT relative to STT; Thus, an estimation of STT cost is then possible using the LRAC data available for this cost analysis) [Ref. 4: p. 8]. The total NPV estimation for EPICS initial skill training, for a four year obligor, is approximately $8,599 and for CPS, $4,197.

However, the $8,599 NPV for EPICS reflects more than initial skill training as defined in chapter one and the assumptions for this analysis. In reality, the NPV for both EPICS and CPS may be near equal since EPICS has integrated skill progression training for the Nato Seasparrow Missile System (NSSMS) with phase II initial skill training for FT's. The EPICS path may be a more cost-effective training scheme simply because the EPICS student at the 2-year career point has more "Navy experience" administratively, culturally and technically, than a CPS counterpart. Essentially, via EPICS, The NSSMS "C" school becomes more the "skill progression" type course it is labeled in CPS.

TABLE VII

EPICS vs. CPS NPV Comparison (LRAC)

```
EPICS

0            1             2             3             4
T------------T-------------T-------------T-------------T
       $2,940        $7,171              0*            0*
             |             |
$2,673___    |             |
 5,926___________________  |

$8,599

CPS

T------------T-------------T-------------T-------------T
$1,243       0*            0*            0*            0*
 1,070
 1,884

$4,197
```

*Assuming no other rating related training investments are made during the four year period.

Also, it is important to note here that the EPICS NPV schematic demonstrates that the best option for cost and effectiveness may actually be to train only for what is necessary to perform the job assigned. For example, an EPICS sailor will receive BE&E and FT "A" phase I equivalent training; and, upon reaching the first sea assignment, the EPICS sailor will perform approximately three months mess cooking/compartment cleaning and approximately nine months in an NSSMS related work center. Assuming the EPICS sailor has received the "proper" amount and "type" of training for the responsibilities and duties assigned during those first twelve months aboard ship, a sailor trained via the CPS pipeline, arriving at the same ship, at the same time, to do

the exact same tasks as the EPICS sailor, will be significantly "overtrained" as suggested in chapter one of this thesis.

The utilization of job-peformance-aids permits EPICS sailors to function within the work center using skills that are specific to the shipboard work center. Valuable, more generalized, electronic theory and systems applications training is delayed until later in a sailor's career. Thus, given a longer initial contract, such as six rather than four years obligated service, Navy training could become more of an incentive to remain on active service rather than a disincentive; expensive, generalized "education", not training, useful for employment outside the military, and also used as a recruiting tool in the military, contributes to reduced retention among skilled military technicians [Ref. 11].

For a better comparison the NSSMS "C" (combined) LRAC is estimated as follows: Using CPS formal cost estimates in table II NSSMS "C" costs were calculated to be 66% of BE&E and FT "A" I and II costs; where BE&E + "A" I + "A" II=$10,872, NSSMS (combined)=$15,364 and $10,872/$15,364=.66. Therefore, $4,197/.66= $6,359 and, the approximate long-run average cost for the CPS equivalent to EPICS is $6,359 + $4,197=$10,556; so, these LRAC based estimates indicate a cost difference of $1,957 for equivalent training; $1,957/$10,556 is approximately .19 which is interpreted as a 19% savings for using EPICS as opposed to CPS. for 26 weeks of instruction the cost of CPS NSSMS "C" is $6,359/26, approximately $245/week.

Another approach to evaluating the training investment decision is to calculate the discounted present value of the stream of revenues earned by the Navy as a result of investing in training. This is the most difficult cost analysis since the Navy does not earn what could be

truly called "revenues". The product of trained sailors may best be described as a subjective, qualitative element; that is, it depends upon the environment in which an assessment on sailor productivity is made. For example, what is "produced" by an FTM aboard a cruiser is not easily determined nor expressed in quantitative terms. Thus, decisionmakers are often forced to choose between policy issues using subjective, intuitive knowledge processed through the chain of command and the DOD bureaucracy.

Similarly, subjectivity and intuition flavor the analysis in this thesis; however, in an attempt to resolve the problem of what EPICS produces relative to what CPS produces in terms of benefit to the Navy, measures of effectiveness will be evaluated in the section on Thesis Effectiveness Comparison.

4. Conclusions

The evaluated data indicate that the EPICS career path costs approximately 19% less than equivalent initial skills and skill progression training provided via CPS (per student). The findings also suggest that human capital overinvestment may exist in Navy CPS thereby contributing to reduced retention among potential careerists, shortages of skilled technicians at sea and increased dependence on lesser qualified, inexperienced, younger personnel. In view of a projected decline within the pool of males eligible to serve in the armed forces and an improving national economy, the implications of this analysis would seem to warrant further evaluation of EPICS and other similar innovative personnel management processes relative to manpower selection and training.

Assessment of opportunity costs is difficult in this analysis without access to valuable raw cost data. Not considered in-depth here are the ramifications of a more

TABLE VIII

Revenue Net Present Value Formula

Net Present Value=

$$R1/(1+r)^1 + R2/(1+r)^2 + \ldots + Rn/(1+r)^n,$$

where,

<u>r</u>

is the interest rate,

<u>R</u>

is the monetary return or revenue each year and,

<u>n</u>,

is the total number of years the investment is expected to provide some return to the investor.

labor-intensive career system such as EPICS. It is more labor-intensive in that the instructor-trainee ratios are much lower than in the conventional personnel system. Thus, the costs of wages as well as the time and skills of personnel supporting EPICS sailors on ship, such as work-center supervisors, should be allocated to the cost of EPICS. Also, an opportunity foregone to the sailor being trained via EPICS is the ability to receive desirable general training at the government's expense. This possibility could have far-reaching effects in times of recruitment difficulties and manpower shortages. These are just two of many significant factors decisionmakers should keep in mind when modifying and changing Navy training policies.

C. SUMMARY AND COMPARISON OF RESULTS

The NPRDC findings suggest cost decreases but still remain to be evaluated against systems effectiveness measures. It is the intention of the researchers to investigate effectiveness on the basis of selected variables reflecting system appeal, resource attributes, individual preparation, contribution, job effectiveness, progression, attrition, and intentions. These variables were selected because they were minimally intrusive, least confounded, and highly descriptive of the overall system performance.

The thesis cost analysis demonstrates that, in terms of initial skill training, the EPICS personnel system delivers an 1148 NEC qualified sailor at less expense to the Navy in two ways: (1) by providing specific training when it is needed and (2) by deferring the training such that it is potentially less a disincentive for retention of skilled technicians. However, there are tradeoffs concurrent with each of these career paths that may be justifiable relative to the eventual benefits of either system.

Assuming that the quality of sailors produced by both systems is equal then, according to this analysis, the EPICS method is by far the better choice. However, should evidence exist to indicate that the EPICS sailor is far less qualified in terms of career motivation, job satisfaction, aptitude, discipline, etc., then a better choice for Navy decisionmakers may be to forego immediate cash savings in return for a more expensive, higher aptitude enlistee who would at least be capable of providing some dependable service in the short run.

III. EFFECTIVENESS ANALYSIS

A. NPRDC EFFECTIVENESS COMPARISONS

The following information was extracted from a paper titled "EPICS -- A JPA Integrated Personnel System," by Dr. Robert E. Blanchard, EPICS program director, Navy Personnel Research and Development Center (NPRDC), San Diego, California [Ref. 12]. The presentation by Dr. Blanchard was not intended as a comprehensive basis for EPICS and conventional personnel system (CPS) training evaluation.

Dr. Blanchard's paper, presented at the Second Annual Conference on Personnel and Training Factors in Systems Effectiveness sponsored by the National Security Industrial Association, May 6, 1982, describes the integrated personnel systems approach (IPSA), EPICS implementation, the EPICS test and evaluation plan and preliminary findings.

At the time of the presentation data collection had been ongoing for approximately 18 months and preliminary findings were available on: (1) EPICS recruiting inducement potential; (2) attrition from the EPICS program and from the Navy; (3) relative performance for initial EPICS sailors in Equipment Technician Training (ETT); (4) supervisor confidence in EPICS task performance during the first 12 months of enlistment; (5) supervisory and EPICS sailor perceptions of the job performance aids and shipboard instructional modules; and (6) relative costs of EPICS compared to the traditional personnel system. Also at that time it was anticipated that data collection would continue for most of these data sets throughout the test and evaluation program. Data on actual performance of EPICS sailors in comparison to "A" school and "C" school graduates, the primary hypothesis

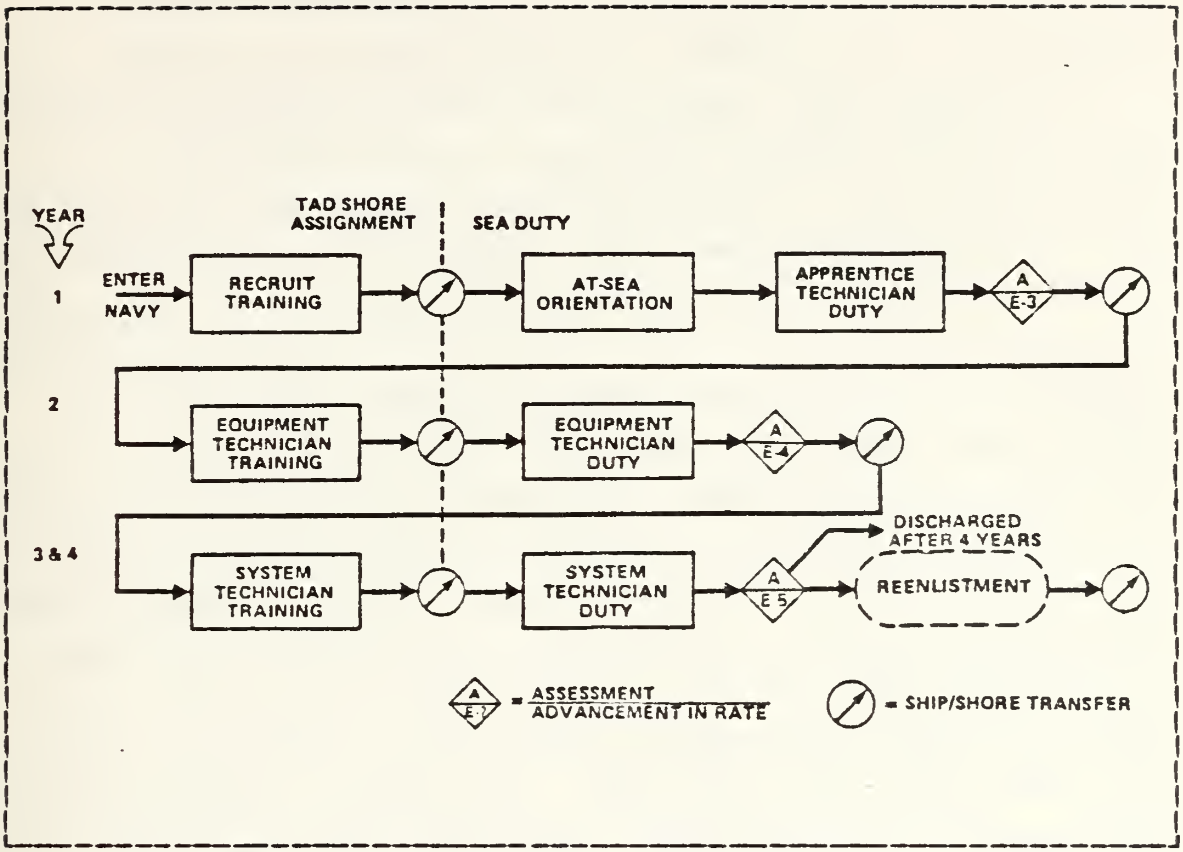

Figure 3.1 Simplified EPICS Career System.

to be tested, would be collected following completion, by a sufficient number of EPICS graduates, of System Technician Training (STT), about mid-1983.

1. Purpose of NPRDC Effectiveness Comparison

The objective of the JPA-Based Integrated Personnel System presentation was to identify, quantify and compare the benefits/costs of EPICS and conventional personnel systems, relative to the potential performance quality characteristics among personnel trained within each system.

2. NPRDC Conclusions

From the presentation on EPICS as a JPA-Based Integrated Personnel System the following were suggested:

1. It seemed that a deferred training program with early at-sea experience was attractive to the prospective Navy recruit as long as there was some assurance that technical school (electronics in this instance) would be available at some point.

2. Attrition data suggested that overall attrition from the Navy with EPICS was about on par with other programs, amounting to about 4%. For attrition from the program, an interesting finding was that the "eligible" cohort of EPICS sailors appeared to be leaving the program at double the rate of the "ineligible" group (12% compared to 5%). Eligibility/ineligibility for the FTM rating is a function of scores on the Armed Services Vocational Aptitude Battery (ASVAB) as follows: MK + EI + GS = 156 + AR = 218 where MK=Mathematical Knowledge, EI=Electronic Information, GS=General Science and AR=Arithmetic Reasoning. These subtests are used to predict success in the FTM rating. The summarized score of 218 is a minimum desired qualification score, but may be waivered to as low as 208 depending on circumstances and manning levels. It is assumed then that EPICS students referred to as eligible and ineligible in the NPRDC reports included personnel who achieved scores greater than or equal to the 218 score as well as personnel who scored below 218.

3. In Equipment Technician Training (ETT), the "ineligible" group performed on par with the comparison group, whereas the "eligible" group appeared to be superior to all comparison groups on module completion time criterion.

4. Supervisors indicated a high confidence level in EPICS sailors performing prescribed tasks using FPJPAs.

5. User acceptance of EPICS was not yet clearly demonstrated.

6. In general, findings at that time on the EPICS field evaluation seemed to justify cautious optimism, although it was much too premature relative to program test and evaluation for any definitive interpretations.

B. THESIS EFFECTIVENESS COMPARISONS

This is a 'first-look' effectiveness analysis of eleven EPICS graduates, NEC 1148 qualified, as compared to seven FTMs who are also NEC 1148 qualified via CPS and a sample of 628 CPS FTGs/FTMs who are NEC 0000.

1. Data Selection

A cohort of 206,229 cases was being evaluated at the Naval Postgraduate School during Winter,1983 in conjunction with an NPRDC-sponsored Navy Enlisted Standards project. The cohort database consisted of several files that were matched on social security numbers by the Defense Manpower Data Center, Monterey, CA. These files included Navy Health Research Center (NHRC), Enlisted Master Record (EMR), Navy Integrated Training Resources Automated System (NITRAS), Defense Manpower Data Center (DMDC) files and Navy Advancement Data on service members who had enlisted in the Navy between 30 September 1976 and 31 December 1978.

Due to the rich content of these files they were made available to several Manpower Personnel Training Analysis (MPTA) students for thesis research. Such was the case with the sample of FTs (NECs 1148 and 0000) used in this analysis. Once the files were successfully matched and the variables of interest labeled, the data was screened to eliminate potential errors and extreme values that could distort any statistical analysis being done with the files.

Since the EPICS test and evaluation program was being conducted with FTMs, the cohort was screened for personnel having either the rate abbreviation FT, FTG or FTM; when this was done frequency distributions were requested for the following variables: (1) DMDC NEC; (2) total number of days to E2, E3, E4; (3) ASVAB subtest scores; (4) time in rate; (5) length of service; (6) advancement exam rate; (7) advancement exam paygrade; (8) present rate; (9) present paygrade (10) total days ua/awol; (11) total number of promotions; (12) total number of demotions; (13) pay entry base date; (14) estimated termination of service date; (15) entry age; (16) entry paygrade; (17) highest education level achieved; (18) AFQT percentile (or equivalent); and (19) AFQT groups.

Data on the eleven EPICS graduates was obtained from NPRDC Code 17 out of the EPICS database, current as of 24 May 1983. Variables were matched as closely as possible to those available for the CPS 1148 and 0000 FTs on the Navy Enlisted Standards cohort database.

2. Methodology

These variables were first evaluated using the Statistical Analysis System's [Ref. 13], Stepwise Discriminant Analysis in a two-phase analysis relative to input and output measures. Input measures, for example, were entry age, ASVAB subtests, highest education level achieved and entry paygrade. The output measures were time in grade, days to promotion, length of service, total promotions, total demotions, total ua/awol, and total desertions. Four possible analytic outcomes were of interest: (1) if inputs were not significantly different, were the outputs significantly different; (2) if inputs were significantly different, were the outputs not significantly different; (3) if inputs were not significantly different, were the outputs

also not significantly different; and (4) if inputs were significantly different, were the outputs also significantly different.

Subsequent to the stepwise discriminant analysis a frequency table was produced and from that 16 variables were deemed worthy of further study (see Table IX) using the SAS DISCRIM procedure.

The DISCRIM procedure of SAS develops a discriminant model for a set of observations containing one or more continuous independent or descriptive variables, and a classification variable whose values define groups for the observations; DISCRIM uses the model to classify each observation into one of the groups and then summarizes the performance of this discriminant model. For the variables listed above the results were as indicated in tables X and XI. These results indicate the probabilities of a member of one category belonging or "fitting into" another category. The DISCRIM procedure performs this analysis based on a set of data and then applies those answers to a test sample. As shown in Table X and XI this is what has been done with the datasets "CALIBR8" and "VALID8".

The EPICS sailors do appear to be a very different group of personnel as compared with the CPS 1148 NEC sailors. According to table X there were 0 percent of category 3 sailors classified into category 2 but 25 percent of the category 2 members were classified to category 3. Table XI confirms the results in table X with 0 percent of categoy 3 classified to category 2 as well as 0 percent of category 2 classified to category 3.

Additional statistical analysis was done using the SAS procedure, General Linear Model (GLM). The GLM procedure is a regression procedure that handles classification variables -- those that name discrete levels -- as well as continuous variables which measure quantities. GLM can be

TABLE IX

Cohort Stepwise Discriminant Analysis

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
ASVAB WK	*		*												--		2
ASVAB AR	*	*	*	*		*			*	*			*		--		8
ASVAB MC			*												--		1
ASVAB NO			*												--		1
ASVAB EI					*						*				--	*	3
ASVAB MK		*		*		*					*		*		--		5
ASVAB GS	*			*					*					*	--		4
ASVAB AD		*	*	*		*			*				*		--		6
ASVAB SI			*								*				--		2
ASVAB GI				*	*			*	*	*			*		--	*	7
ASVAB SP	*		*	*	*	*	*		*	*	*			*	--	*	11
ASVAB AI		*			*							*	*		--	*	5
ENTRY AGE		*		*	*	*		*	*				*		--		7
HIGH ED												*			--		1
AFCT PCT															--		0
AFCT GRP															--		0
ENTRY PG	*		*	*		*		*	*	*	*			*	--	*	10
EPICS NEC															--		0
LOS															--		0
DAYS E2		*			*		*						*		--		4
DAYS E3												*			--		1
DAYS E4										*					--		1
TOT DEMO			*												--		1
TOT UA			*	*	*			*	*	*	*				--	*	8
TOT PROM										*	*				--		2
TOT DES															--		0

where, sixteen random samples were selected from the 628 '0000' FTs and labeled category 1; category 2 consisted of the seven '1148' nec FTs from the cohort (these 7, once identified, became a separate group of FTs from an original cohort sample of 845 FTs); and category 3 was a sample of eleven EPICS graduates. The '1148' nec FTs in category 2 were CPS personnel.

The same analysis was run (run #17) with the total 628 sample of '0000' FTs, the EPICS '1148' and the CPS '1148' datasets.
All the variables shown as significant for run 17 as well as the variables (runs 1 - 16) with frequencies of 2 or more were selected for the SAS discriminant analysis.

These were ASVAB AR, WK, EI, MK, GS, AD, SI, GI, SP, AI, Entry age, Entry paygrade, Number of days to E2, Total number of demotions and Total number of UA/Awol,

used with simple regression, multiple regression, analysis of variance (ANOVA), especially for unbalanced data,

analysis of covariance, response surface models, weighted regression, partial correlations, multivariate analysis of variance (MANOVA) and numerous other techniques.

Using the Duncan Multiple Range Test and Least Squares Means steps of the GLM procedure in SAS, some indicators of how well the three groups of FTs compare statistically are provided as classified by category.

The variables that did not demonstrate any significant differences among the three groups were: (1) input variables -- highest level of education achieved, ASVAB General Information, ASVAB Numerical Operation, ASVAB Word Knowledge, ASVAB Arithmetic Reasoning, ASVAB Mechanical Comprehension, ASVAB Science Information, ASVAB Arithmetic Information and (2) output variables -- number of days to E3, total number of promotions, total number of days ua/awol, and total number of desertions.

The variables that show some variation among the three categories are summarized below with relevant statistical results and some suggestions as to why the results are as indicated.

The results in Table XII are not surprising since in many of the electronics ratings it is possible to enter the Navy at a paygrade higher than E1. The data evaluated suggests that some members of categories one and two entered the Navy via special rating guarantee programs such as the Advanced Electronics Field (AEF) program. In this analytical summary the members in category one could be viewed as the "normal" population and categories two and three as subsets of that population, occupying the high and low tails, respectively, of a normal population distribution curve.

Table XIII presents possible substantiation of the results in Table XII; the persons in category two demonstrate a relatively high mean entry paygrade and were

also an older group when they enlisted in in the Navy. Since these people are older it is possible that they have some previous experience or training involving electronics.

Again, there is further evidence that the members of category two are a very different group of enlistees. None of the CPS 1148 sailors entered the Navy as E1s and thus, were most likely recruited via some Advanced Electronics program that guaranteed specific training and earlier promotion to E2/3. The EPICS sailors clearly take longer than either category two or three sailors for promotion to E2 since they are following a career path that more closely resembles that of the general detail (gendet) sailor at this point of a naval career. GENDETS receive immediate fleet assignments via 4-6 weeks general apprentice training courses subsequent to completion of basic training.

Table XV would seem to suggest that while some enlistees in categories one and two benefit at entry with some guaranteed immediate technical training and early advancement to E2, there is almost a year delay for for promotion to E4 compared to the EPICS sailors. There could be several explanations for this; one of which is the time period of the data. Frequently, advancement exam/promotion cycles change relative to the manpower demands of the Navy; that seems to be the case here. Both categories one and two take nearly 24 months to achieve petty officer status whereas the EPICS personnel became E4s in about one year. Currently there is a significant shortage of qualified petty officers as well as FTs and FTMs in the Navy; thus, it would not be unusual for rates of advancement to be very good among the EPICS people. It is entirely possible that such was not the case for persons entering the Navy between September 30, 1976 and December 31, 1978. Also, It is not unusual for time in rate (TIR) and time in service (TIS) requirements to change every two or three advancement

cycles. In fact, today there is no TIS requirement, only TIR. Thus, this data may not be relevant as an output measure.

Numerous undocumented perceptions and ideas abound concerning factors that contribute to variables such as demotions. In this example, it appears that a significantly high occurrence of demotions is evident among the group of people who, according to the previous data, were the "better" qualified enlistees. Intuitive reaction to this table is that given the sometimes rigid, discipline-oriented environment of the Navy, older, "intelligent" enlistees sometimes experience difficulty coping with routine procedures that in another environment could be viewed as quite trivial. Also, should that perception exist, members of category two are most likely capable of finding employment external to the Navy and are not reluctant to so remind their immediate superiors either verbally or by their behavior; as a consequence, these kinds of service members usually pay a price for such independence via loss in rank and commensurate income.

Table XVII presents some very interesting evidence that may be significant for EPICS. It seems intuitive that the CPS 1148-qualified sailors would rank highest on this variable due to their higher aptitude. Again, assuming that the CPS 0000 sailors represent a "normal" population of FTs then, the EPICS sailors are somewhat above average in their ability to pay attention to detail. Presumably, one is attentive to something one is interested in and therefore desires to excel in performance relative to that interest. While the EPICS group is, overall, ranked somewhat lower in evaluations of general aptitude it is encouraging to note such a high average score for this variable.

The variable spatial perception may frequently be overlooked as an indicator of skill/ability relevant to technical learning. Nevertheless, as with table XVII the evidence seems to suggest that spatial perception may have some significance in terms of learning and applying new ideas. As EPICS continues, further investigation of this variable with other EPICS groups may provide additional insight. Table XIX does not demonstrate anything new or enlightening. Given the backgrounds of the three groups and the results of the earlier tables these figures are not surprising.

The results of table XX further substantiate tables XII, XIII, XIV and XIX. Category two members most likely have enlisted in the Navy with some previous training/experience in the electronics field; Table XXI also parallels table XX.

The LSMEANS ANALYSIS looks at the probabilities of members within one category differing from members in the other two categories. For entry paygrade each, table XXII, category seems to be very different with little chance of members in category one or two being in category three and a somewhat better, though still small, chance of one and two being members of the same category. The following tables provide further substantiation of what was presented in Tables XII and XXI.

Table XXIII, suggests that there are age similarities between the EPICS graduates and the NEC 0000 group. Again, the CPS 1148 group, category two, seems to be quite different in terms of entry age as compared to either category one or three.

Each of the categories again do not seem to share any major similarities with each other on the number of days to E2; the data in table XXV may not be useful for reasons indicated above for table XV. Table XXVI suggests that the

EPICS students may have a lesser tendency to be demoted than "highly qualified" CPS 1148 NEC personnel for reasons cited earlier. Further investigation of other graduates may reinforce this conclusion.

Tables XXVII and XXVIII are interesting input variable indicators of similarities between NEC 1148 EPICS and CPS personnel. Future studies of EPICS graduates investigating these two variables should provide additional insight into the kinds of people the Navy may want to consider for selection into the highly technical ratings.

3. Thesis Conclusions

The data, as evaluated presents no shocking surprises. It is interesting however, that in terms of the input variables, the EPICS members seem to demonstrate that while their aptitude scores are average, they are capable of performing satisfactorily such that all eleven graduates have attained the criterion of the 1148 NEC and all eleven have attained petty officer status.

C. SUMMARY AND COMPARISON OF RESULTS

How much of the EPICS sailors' success is attributable to the EPICS personnel system remains to be determined. Neither the NPRDC nor the thesis effectiveness analysis presented here are conclusive. Given the complexity of human behavior it is very difficult to evaluate whether their success is a function of the training methodology or simply perceived attention EPICS sailors are getting as a result of the R&D nature of the program. This is an important issue that can be addressed only after more graduates complete EPICS and evaluations of their performance throughout their careers are maintained. This presentation is simply a "snapshot" in time. Unfortunately, upon

completion of R&D and implementation of new programs useful data and analysis are often dismissed as unnecessary and time-consuming.

IV. CONCLUSIONS

The EPICS evaluation and this thesis are but beginnings of an interesting and promising experiment. Should EPICS be put into effect, it could possibly result in improved personnel planning, recruitment and retention during what may be a very crucial period for manpower acquisition within and external to the military.

Additional output variables such as advancement exam raw scores, performance evaluation marks, etc., would provide a more substantial basis for comparing the 'effectiveness' of EPICS vs. CPS 1148 FTMs. The data evaluated however, does seem to indicate that entry scores on the ASVAB subtests MK, EI, GS and AR may not be the only subtests relevant to suitable personnel selection and training for a technical rating such as the fire control technician.

Should future data on EPICS sailor performance in the fleet indicate comparable or better proficiency relative to CPS trained sailors then Navy decisionmakers may have a choice in terms of how much they are willing or able to spend on human capital training investments for skilled technicians.

APPENDIX A

EFFECTIVENESS ANALYSIS TABLES

TABLE X

Calibr8 Discriminant Analysis Summary

DISCRIMINANT ANALYSIS
CLASSIFICATION SUMMARY FOR CALIBRATION DATA:
WORK.CALIBR8

GENERALIZED SQUARED DISTANCE FUNCTION:

$$D_J^2(X) = (X-\bar{X}_J)' \ COV^{-1} \ (X-\bar{X}_J)$$

POSTERIOR PROBABILITY OF MEMBERSHIP IN EACH CATEGORY:

$$PR(J|X) = EXP(-.5 \ D_J^2(X)) \ / \ \underset{K}{SUM} \ EXP(-.5 \ D_K^2(X))$$

OF OBS AND PERCENTS CLASSIFIED INTO CATEGORY:

FROM CATEGORY	1	2	3	TOTAL
1	381 89.86	28 6.60	15 3.54	424 100.00
2	1 25.00	2 50.00	1 25.00	4 100.00
3	1 14.29	0 0.00	6 85.71	7 100.00
TOTAL PERCENT	383 88.05	30 6.90	22 5.06	435 100.00
PRIORS	0.3333	0.3333	0.3333	

TABLE XI

Valid8 Discriminant Analysis Summary

DISCRIMINANT ANALYSIS
CLASSIFICATION SUMMARY FOR VALIDATION TEST DATA:
WORK.VALID8

GENERALIZED SQUARED DISTANCE FUNCTION:

$$D_J^2(X) = (X-\bar{X}_J)' \; COV^{-1} \; (X-\bar{X}_J)$$

POSTERIOR PROBABILITY OF MEMBERSHIP IN EACH CATEGORY:

$$PR(J|X) = EXP(-.5 \; D_J^2(X)) \; / \; \underset{K}{SUM} \; EXP(-.5 \; D_K^2(X))$$

OF OBS AND PERCENTS CLASSIFIED INTO CATEGORY:

FROM CATEGORY	1	2	3	TOTAL
1	174 85.29	13 6.37	17 8.33	204 100.00
2	1 33.33	2 66.67	0 0.00	3 100.00
3	1 25.00	0 0.00	3 75.00	4 100.00
TOTAL PERCENT	176 83.41	15 7.11	20 9.48	211 100.00
PRIORS	0.3333	0.3333	0.3333	

TABLE XII

Entry Paygrade

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: ENTRPAYG

NOTE: THIS TEST CONTROLS ERROR RATES AT DIFFERENT LEVELS DEPENDING ON THE NUMBER OF MEANS BETWEEN EACH PAIR BEING COMPARED. ITS OPERATING CHARACTERISTICS SOMEWHAT RESEMBLE FISHER'S UNPROTECTED LSD TEST.

ALPHA=0.05 DF=643 MSE=0.887748

HARMONIC MEAN OF CELL SIZES=12.7465

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	CATEGORY
A	2.7143	7	2
B	1.8424	628	1
C	1.0000	11	3

TABLE XIII

Entry Age

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: ENTRYAGE

NOTE: THIS TEST CONTROLS ERROR RATES AT DIFFERENT LEVELS BEING COMPARED. ITS OPERATING CHARACTERISTICS SOMEWHAT RESEMBLE FISHER'S UNPROTECTED LSD TEST. DEPENDING ON THE NUMBER OF MEANS BETWEEN EACH PAIR

ALPHA=0.05 DF=643 MSE=3.92129

HARMONIC MEAN OF CELL SIZES=12.7465

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	CATEGORY
A	20.714	7	2
B	19.091	11	3
B			
B	18.944	628	1

TABLE XIV

Number Days to E2

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: NDAYSE2

NOTE: THIS TEST CONTROLS ERROR RATES AT DIFFERENT LEVELS DEPENDING ON THE NUMBER OF MEANS BETWEEN EACH PAIR BEING COMPARED.ITS OPERATING CHARACTERISTICS SOMEWHATRESEMBLE FISHER'S UNPROTECTED LSD TEST.

ALPHA=0.05 DF=643 MSE=26870.3

HARMONIC MEAN OF CELL SIZES=12.7465

MEANS WITH SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT

DUNCAN	GROUPING	MEAN	N	CATEGORY
	A	196.36	11	3
	A			
B	A	96.12	628	1
B				
B		0.00	7	2

TABLE XV

Number Days to E4

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: NEWDAY4
NOTE: THIS TEST CONTROLS ERROR RATES AT DIFFERENT LEVELS DEPENDING ON THE NUMBER OF MEANS BETWEEN EACH PAIR BEING COMPARED. ITS OPERATING CHARACTERISTICS SOMEWHAT RESEMBLE FISHER'S UNPROTECTED LSD TEST.

ALPHA=0.05 DF=643 MSE=197293

HARMONIC MEAN OF CELL SIZES=12.7465

MEANS WITH SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT

DUNCAN GROUPING		MEAN	N	CATEGORY
	A	665.57	7	2
	A			
B	A	605.47	628	1
B				
B		286.36	11	3

TABLE XVI

Tctal Number Demotions

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: TOTLDEMO

NOTE: THIS TEST CONTROLS ERROR RATES AT DIFFERENT LEVELS DEPENDING ON THE NUMBER OF MEANS BETWEEN EACH PAIR BEING COMPARED. ITS OPERATING CHARACTERISTICS SOMEWHAT RESEMBLE FISHER'S UNPROTECTED LSD TEST.

ALPHA=0.05 DF=643 MSE=0.230558

HARMONIC MEAN OF CELL SIZES=12.7465

MEANS WITH SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT

DUNCAN GROUPING	MEAN	N	CATEGORY
A	0.71429	7	2
B	0.20382	628	1
B			
B	0.09091	11	3

TABLE XVII

Attention to Detail

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: ASVABAD

NOTE: THIS TEST CONTROLS ERROR RATES AT DIFFERENT LEVELS DEPENDING ON THE NUMBER OF MEANS BETWEEN EACH PAIR BEING COMPARED.
ITS OPERATING CHARACTERISTICS SOMEWHAT RESEMBLE FISHER'S UNPROTECTED LSD TEST.

ALPHA=0.05 DF=643 MSE=15.9587

HARMONIC MEAN OF CELL SIZES=12.7465

MEANS WITH SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT

DUNCAN	GROUPING	MEAN	N	CATEGORY
	A	18.857	7	2
	A			
B	A	18.000	11	3
B				
B		15.185	628	1

TABLE XVIII

Spatial Perception

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: ASVABSP

NOTE: THIS TEST CONTROLS ERROR RATES AT DIFFERENT LEVELS DEPENDING ON THE NUMBER OF MEANS BETWEEN EACH PAIR BEING COMPARED. ITS OPERATING CHARACTERISTICS SOMEWHAT RESEMBLE FISHER'S UNPROTECTED LSD TEST.

ALPHA=0.05 DF=643 MSE=13.0164

HARMONIC MEAN OF CELL SIZES=12.7465

MEANS WITH SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT

DUNCAN GROUPING		MEAN	N	CATEGORY
	A	17.909	11	3
	A			
B	A	16.000	7	2
B				
B		14.524	628	1

TABLE XIX

Mathematical Knowledge

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: ASVABMK

NOTE: THIS TEST CONTROLS ERROR RATES AT DIFFERENT LEVELS DEPENDING ON THE NUMBER OF MEANS BETWEEN EACH PAIR BEING COMPARED.
ITS OPERATING CHARACTERISTICS SOMEWHAT RESEMBLE FISHER'S UNPROTECTED LSD TEST.

ALPHA=0.05 DF=643 MSE=9.1634

HARMONIC MEAN OF CELL SIZES=12.7465

MEANS WITH SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT

DUNCAN	GROUPING	MEAN	N	CATEGORY
	A	16.000	7	2
	A			
B	A	15.646	628	1
B				
B		13.364	11	3

TABLE XX

Electronic Information

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: ASVABEI

NOTE: THIS TEST CONTROLS ERROR RATES AT DIFFERENT LEVELS DEPENDING ON THE NUMBER OF MEANS BETWEEN EACH PAIR BEING COMPARED. ITS OPERATING CHARACTERISTICS SOMEWHAT RESEMBLE FISHER'S UNPROTECTED LSD TEST.

ALPHA=0.05 DF=643 MSE=16.0351

HARMONIC MEAN OF CELL SIZES=12.7465

MEANS WITH SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT

DUNCAN	GROUPING	MEAN	N	CATEGORY
	A	24.143	7	2
	A			
B	A	23.568	628	1
B				
B		20.818	11	3

TABLE XXI

General Science

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: ASVABGS

NOTE: THIS TEST CONTROLS ERROR RATES AT DIFFERENT LEVELS DEPENDING ON THE NUMBER OF MEANS BETWEEN EACH PAIR BEING COMPARED. ITS OPERATING CHARACTERISTICS SOMEWHAT RESEMBLE FISHER'S UNPROTECTED LSD TEST.

ALPHA=0.05 DF=643 MSE=7.80593

HARMONIC MEAN OF CELL SIZES=12.7465

MEANS WITH SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT

DUNCAN	GROUPING	MEAN	N	CATEGORY
	A	16.429	7	2
	A			
B	A	14.702	628	1
B				
B		12.727	11	3

TABLE XXII

Entry Paygrade LSMEANS Analysis

CAT	ENTRPAYG LSMEAN	STD ERR LSMEAN	PROB > |T| H0:LSMEAN=0	LSMEAN NUMBER
1	1.84235669	0.03759802	0.0001	1
2	2.71428571	0.35611954	0.0001	2
3	1.00000000	0.28408511	0.0005	3

PROB > |T| H0: LSMEAN(I)=LSMEAN(J)

I/J	1	2	3
1	.	0.0152	0.0034
2	0.0152	.	0.0002
3	0.0034	0.0002	.

TABLE XXIII

Entry Age LSMEAN Analysis

CAT	ENTRYAGE LSMEAN	STD ERR LSMEAN	PROB > |T| HO:LSMEAN=0	LSMEAN NUMBER
1	18.9442675	0.0790195	0.0001	1
2	20.7142857	0.7484542	0.0001	2
3	19.0909091	0.5970599	0.0001	3

PROB > |T| HO: LSMEAN(I)=LSMEAN(J)

I/J	1	2	3
1	.	0.0190	0.8077
2	0.0190	.	0.0905
3	0.8077	0.0905	.

TABLE XXIV

Number Days to E2 LSMEAN Analysis

CAT	NDAYSE2 LSMEAN	STD ERR LSMEAN	PROB > |T| HO:LSMEAN=0	LSMEAN NUMBER
1	6.122611	6.541183	0.0001	1
2	0.000000	61.956536	1.0000	2
3	6.363636	49.424218	0.0001	3

PROB > |T| HO: LSMEAN(I)=LSMEAN(J)

I/J	1	2	3
1	.	0.1234	0.0448
2	0.1234	.	0.0135
3	0.0448	0.0135	.

TABLE XXV

Number Days to E4 LSMEAN Analysis

CAT	NEWDAY4 LSMEAN	STD ERR LSMEAN	PROB > |T| HO:LSMEAN=0	LSMEAN NUMBER
1	605.466561	17.724588	0.0001	1
2	665.571429	167.883086	0.0001	2
3	286.363636	133.924373	0.0329	3

PROB > |T| HO: LSMEAN(I)=LSMEAN(J)

I/J	1	2	3
1	.	0.7219	0.0185
2	0.7219	.	0.0779
3	0.0185	0.0779	.

TABLE XXVI

Total Demotions LSMEAN Analysis

CAT	TOTIDEMO LSMEAN	STD ERR LSMEAN	PROB > |T| HO:LSMEAN=0	LSMEAN NUMBER
1	0.20382166	0.01916063	0.0001	1
2	0.71428571	0.18148496	0.0001	2
3	0.09090909	0.14477491	0.5303	3

PROB > |T| HO: LSMEAN(I)=LSMEAN(J)

I/J	1	2	3
1	.	0.0053	0.4397
2	0.0053	.	0.0074
3	0.4397	0.0074	.

TABLE XXVII

Attention to Detail LSMEAN Analysis

CAT	ASVABAD LSMEAN	STD ERR LSMEAN	PROB > |T| HO:LSMEAN=0	LSMEAN NUMBER
1	15.1847134	0.1594111	0.0001	1
2	18.8571429	1.5099044	0.0001	2
3	18.0000000	1.2044870	0.0001	3

PROB > |T| HO: LSMEAN(I)=LSMEAN(J)

I/J	1	2	3
1	.	0.0158	0.0208
2	0.0158	.	0.6574
3	0.0208	0.6574	.

TABLE XXVIII

Spatial Perception LSMEAN Analysis

CAT	ASVABSP LSMEAN	STD ERR LSMEAN	PROB > |T| HO:LSMEAN=0	LSMEAN NUMBER
1	14.5238854	0.1439679	0.0001	1
2	16.0000000	1.3636301	0.0001	2
3	17.9090909	1.0878005	0.0001	3

PROB > |T| HO: LSMEAN(I)=LSMEAN(J)

I/J	1	2	3
1	.	0.2821	0.0021
2	0.2821	.	0.2742
3	0.0021	0.2742	.

TABLE XXIX

Mathematical Knowledge LSMEAN Analysis

CAT	ASVABMK LSMEAN	STD ERR LSMEAN	PROB > |T| HO:LSMEAN=0	LSMEAN NUMBER
1	15.6464968	0.1207949	0.0001	1
2	16.0000000	1.1441405	0.0001	2
3	13.3636364	0.9127084	0.0001	3

PROB > |T| HO: LSMEAN(I)=LSMEAN(J)

I/J	1	2	3
1	.	0.7587	0.0134
2	0.7587	.	0.0721
3	0.0134	0.0721	.

TABLE XXX

Electronics Information LSMEAN Analysis

CAT	ASVABEI LSMEAN	STD ERR LSMEAN	PROB > |T| HO:LSMEAN=0	LSMEAN NUMBER
1	23.5684713	0.1597922	0.0001	1
2	24.1428571	1.5135138	0.0001	2
3	20.8181818	1.2073664	0.0001	3

PROB > |T| HO: LSMEAN(I)=LSMEAN(J)

I/J	1	2	3
1	.	0.7060	0.0243
2	0.7060	.	0.0864
3	0.0243	0.0864	.

TABLE XXXI

General Science LSMEAN Analysis

CAT	ASVABGS LSMEAN	STD ERR LSMEAN	PROB > |T| HO:LSMEAN=0	LSMEAN NUMBER
1	14.7022293	0.1114891	0.0001	1
2	16.4285714	1.0559985	0.0001	2
3	12.7272727	0.8423954	0.0001	3

PRCB > |T| HO: LSMEAN(I)=LSMEAN(J)

I/J	1	2	3
1	.	0.1045	0.0204
2	0.1045	.	0.0063
3	0.0204	0.0063	.

TABLE XXXII

Multivariate Analysis of Variance

```
MANOVA TEST CRITERIA FOR THE HYPOTHESIS
OF NO OVERALL CATEGORY EFFECT

 H = TYPE IV SS&CP MATRIX FOR: CATEGORY
 E = ERROR SS&CP MATRIX
 P = DEP. VARIABLES =         22
 Q = HYPOTHESIS DF  =          2
 NE= DF OF E        =        643
 S = MIN(P,Q)       =          2
 M = .5(ABS(P-Q)-1) =        9.5
 N = .5(NE-P-1)     =      310.0
--------------------------------------------------------------
HOTELLING-LAWLEY TRACE = TR(E**-1*H) = 0.20735938

F APPROXIMATION = 2(S*N+1)*TR(E**-1*H)/(S*S*(2M+S+1))
                        WITH S(2M+S+1) AND 2(S*N+1) DF

          F(44,1242) = 2.93      PROB > F = 0.0001
--------------------------------------------------------------
 PILLAI'S TRACE    V = TR(H*INV(H+E)) =          0.18616448

         F APPROXIMATION = (2N+S+1)/(2M+S+1) * V/(S-V)
                        WITH S(2M+S+1) AND S(2N+S+1) DF

         F(44,1246) =     2.91     PROB > F = 0.0001
--------------------------------------------------------------
```

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